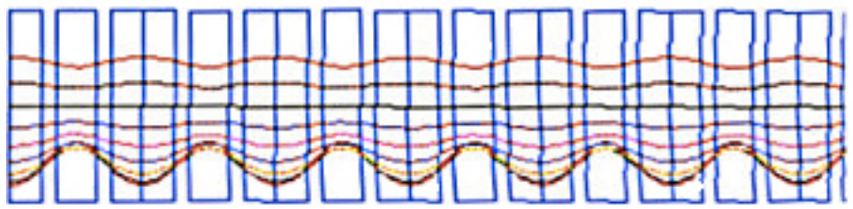


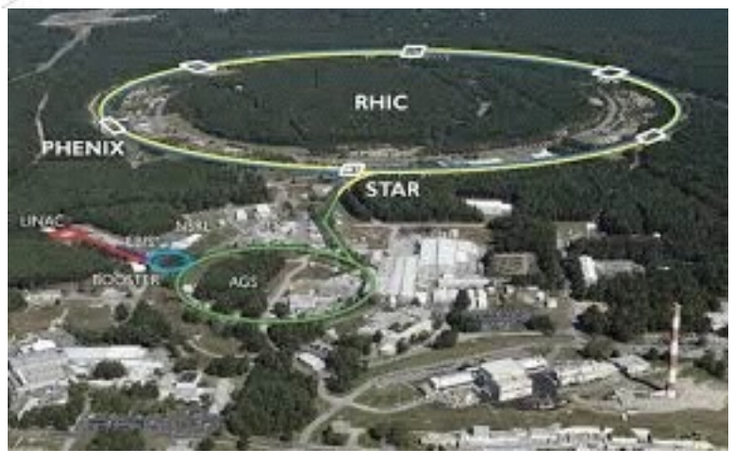
FFAG'14 Workshop Summary

Suzie Sheehy

September 22-26th, Brookhaven National Lab

1. Dec1999, FFAG'99 - KEK
2. Mar 2000, PRISM muon source, TRIUMF
3. July 2000, FFAGs for Muons- CERN
4. Oct. 2000, FFAG'00 - KEK
5. Feb 2002, FFAG'02 - KEK
6. Sept. 2002, FFAG - LBL
7. July 2003, FFAG'03 - KEK
8. Sept 2003, FFAG - BNL
9. Mar. 2004, FFAG - TRIUMF
10. Oct. 2004, FFAG'04 - KEK
11. Apr. 2005, FFAG - FNAL
12. Dec. 2005, FFAG'05 - KURRI
13. May '06, FFAG - BNL
14. Nov. '06, FFAG'06 - KURRI
15. April '07, FFAG - LPSC, Grenoble
16. Nov '07, FFAG'07 - KURRI
17. Sept. '08, FFAG'08 - Manchester
18. 2008, FFAG'08 - KURRI
19. 2009, FFAG'09 - FNAL
20. 2009, FFAG'09J - KURRI
21. 2010, FFAG'10 - KURRI
22. 2011, FFAG'11 - Oxford
23. 2012, FFAG'12 - Osaka
24. 2013, FFAG'13 - TRIUMF
25. **2014, FFAG'14 - BNL**

BROOKHAVEN
NATIONAL LABORATORY



nb. all plots/figures throughout this talk are from the Indico versions of speakers slides

The workshop in numbers*:

Attendees: 42 (+ a few others?)
Talks: 46

Percentage of mac users: 97%
Groundhogs observed: 3
Visitors scared by ticks at BNL: 14
Amazing sunsets: >2

Coffee consumed: 3,654,000 L
Delicious foodstuffs consumed: 56,781

*some numbers may be totally made up

1. Operating machines: Status, Results

Yoshihiro Ishi,
KURRI R&D status

Challenges:
- Large vacuum chamber, need for new diagnostics
- Simulation vs experiment requires all details of system

Nobuo Ikeda
Kyushu R&D

Challenges posed for FFAGs:
Can we use an FFAG as a post-acceleration AMS device?

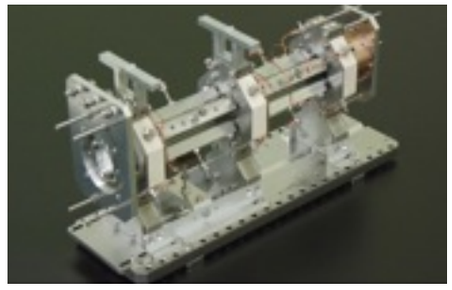
1. Operating machines: Status, Results

Shinji Machida
EMMA

Many lessons from EMMA:
Need to consider injection/extraction earlier in design
Diagnostics are not the same as synchrotron

Discussion points:
Could we do an RLA using ALICE with EMMA return arcs?

Suzie Sheehy
S-Pod collaboration



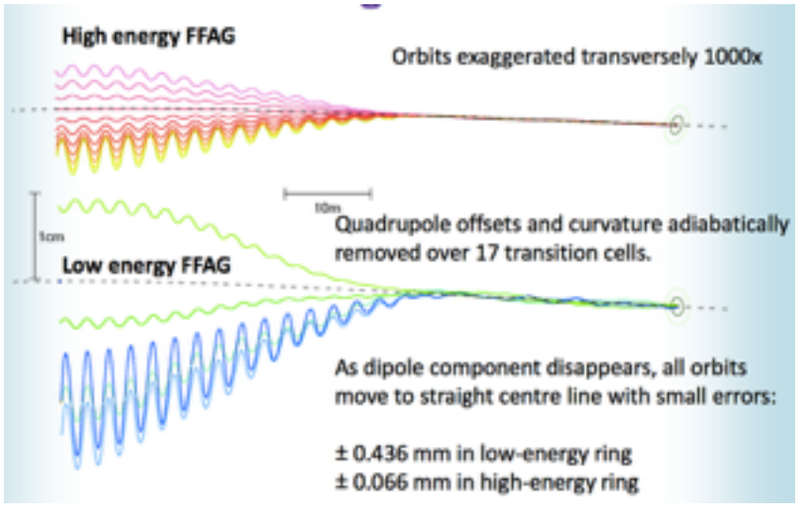
Discussion points:
How much can we really study without longitudinal effects?
(How) can we take into account the momentum compaction?

2. eRHIC

- Until 2013 had 6 recirculation passes in design
- Cheaper to have 2 FFAG beam lines
- Cheaper permanent magnet tech
- Discussion point: also only 1/3 as much linac needed

Vladim Ptitsyn
eRHIC, status

Stephen Brooks
eRHIC FFAG lattice



- Optimised design to reduce synchrotron radiation
- adiabatic matching concept
- Next pass will use doublet cell structure

2. eRHIC

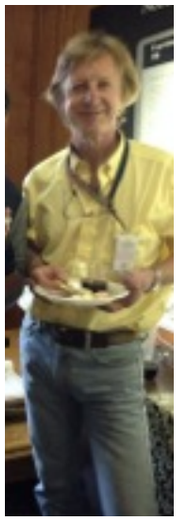
Chuyu Liu
Orbit correction for eRHIC FFAG lattice

- Challenging correction of multi-pass orbits

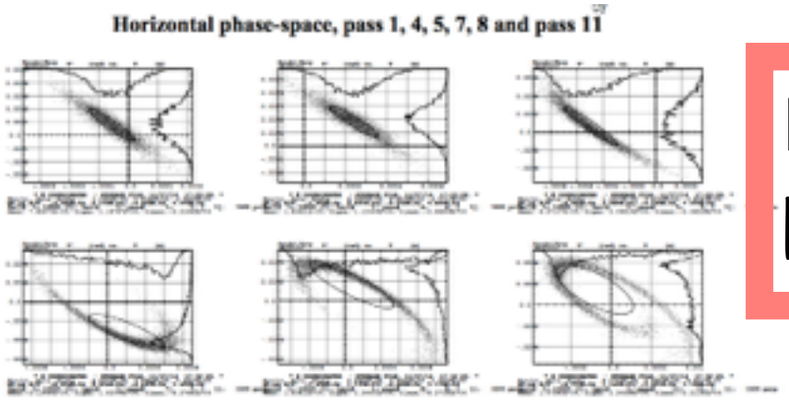
Oleg Tchoubar
Synchrotron radiation in eRHIC FFAG

Extended calculation of synchrotron radiation
Could be used as a diagnostic tool for eRHIC

2. eRHIC



Francois Meot
End-to-end polarized bunch transport in eRHIC



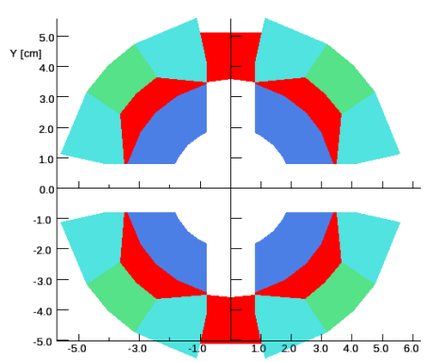
Discussion:
Do we really understand what's happening here?

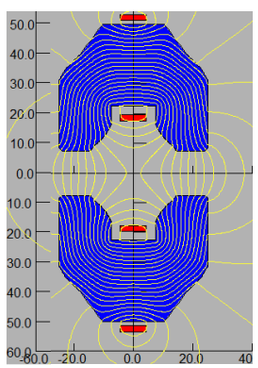
Vladimir Litvinenko
Lattice studies

Merging and separating beams with harmonics
Looks to be a challenging task!

2. eRHIC

Nicholaos Tsoupas
eRHIC magnet cell options
Material ordered to build prototypes by end of year





images blatantly nicked from the talk…

Discussion points:

Do we know long-term magnetisation issues for permanent magnets?

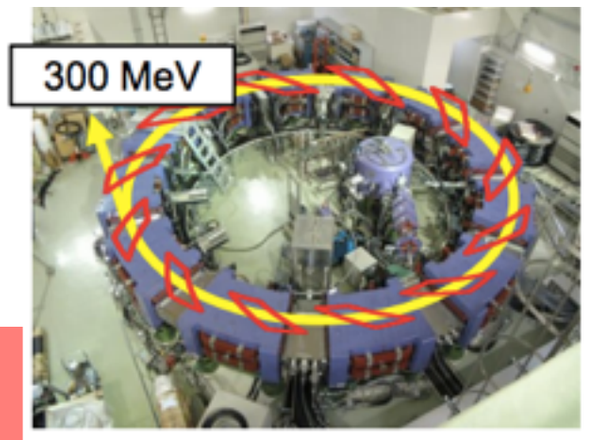
Then we ate…

3. FFAGs for basic research

Yoshihiru Mori
Intense monochromatic muon source

- 10^16 mu/sec required
- mu-ERIT 500 MeV/u, graphite target
- proposes a VFFAG, CW
- many technical challenges

Okita Hidefumi
Preliminary design of a 300MeV spiral FFAG at Kyushu University



Discussion points:

How should we optimise & control tunes in scaling FFAGs with spiral angles, chamfers, field clamps etc

3. FFAGs for basic research

JB Lagrange
Nu-STORM

Discussion points:

With real magnets, will the tune variation be very different?

With long baseline designs flux uncertainty becomes a big issue

How to set constraints on 'zero-chromatic' FFAG, if it's only a few-pass machine

Jaroslaw Pasternak
Design studies for PRISM

- 1-4MW proton beam power
- Rep rate 100 Hz - 1 kHz
- Injection is challenging!

3. eRHIC & FFAGs for basic research- Discussion

Short talk on muon acceleration

- Need to limit emittance growth
- Need to reduce TOF for a given circumference
- Add sextuples to reduce TOF range

10:30 - 11:00 Coffee Break (Brookhaven Center, North Room)

11:00 - 12:30 eRHIC, FFAGs for Basic Research - Discussions - Chair: Scott Berg [T.Uesugi]

Location: Brookhaven Center, South Room

11:00 **Muon Acceleration** *15'*

Speaker: Dr. J. Scott Berg (Brookhaven National Laboratory)

Material: **Slides**

11:15 **Discussion: eRHIC design and FFAGs for basic research.** *1h15'*

Speaker: Dr. J. Scott Berg (Brookhaven National Laboratory)

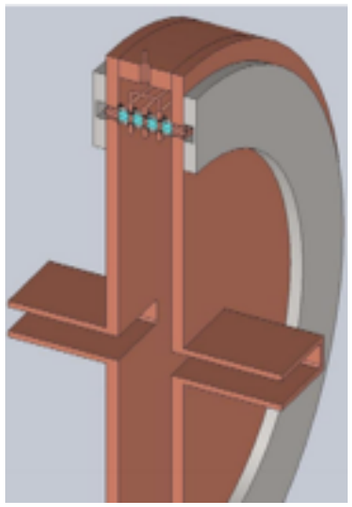
12:30 - 13:30 Lunch Break (Cafeteria Berkner [illegible])

SCOTT BERG?

Discussion points:

- Would a VFFAG be better for muons as it could be isochronous?
- Long discussion on path length matching sections for eRHIC (seems to lose 'elegance' of FFAG arcs?)
- Matching is also for beta-functions
- Can there be focusing in the LINAC? (Not at present, why not? Synchrotron radiation? Space constraints?)
- Maybe should study FFAG focusing in LINAC section

4. Accelerator components - RF, magnet, diagnostics



David Newsham

Rapidly tunable RF cavity
FE material, analogous to ferrite tuning
Limited deltaF/F range (so need to operate with high harmonic)

Naoyuki Amemiya

HTS magnets for scaling FFAG

Overview of ongoing R&D project

Discussion points:
Current doesn't flow uniformly through wide 'tape' of HTS material, can the tape be cut/produced differently? (Not at present)

Tom Uesugi

RF operation at KURRI FFAG

Discussion points:
Not sure if increase in intensity is really due to new RF programme
Could there be a large phase slip accumulation?

5. Beam dynamics, simulations, codes

Suzie Sheehy

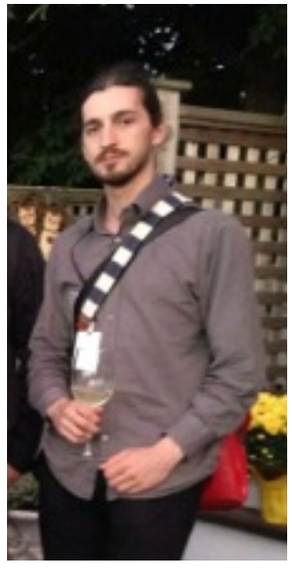
Status of experiments at the KURRI ADSR FFAG

Andreas Adelmann

OPAL status

Discussion points:

Possibility of using OPAL to study eRHIC to compare to ELEGANT?



Sam Tygier

Dynamic aperture of FFAGs

- Consistent definition of DA
- Some good case studies
- Implementation in PyZGOUBI

Then we ate…

6. Applications - high power, transmutation, ADSR

Michael Craddock

Isochronous radial-sector non-scaling FFAGs using different F and D field profiles

Discussion points:

Modelling of high energies in some of these lattices (like Graham Rees' "pumplet") become very dependent on fringe fields

Stephen Brooks

Vertical orbit-excursion FFAGs and 3D cyclotrons

my favourite line: "isochronous cyclotron disease"

Shinji Machida

FFAGs for High Power Application

- Challenged us to consider a new method of FFAG design

Discussion points:

Tuning coils & cyclotrons - not all are used

Will we get the 'knobs' required when we have limited budget?

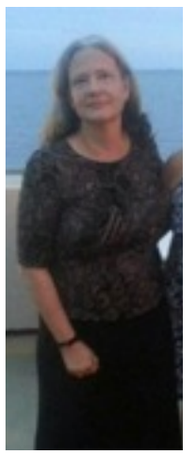
Do we want so many variables for an 'easy to use' ie. medical machine?

Maybe we just need to work harder to understand our designs??

6. Applications - high power, transmutation, ADSR

Nikolaos Simos
BLAIRR
"Brookhaven linear irradiation test facility"

Discussion points:
Might be an opportunity for a high power FFAG to 1 GeV



Carol Johnstone
High Power FFAGs using SCRF

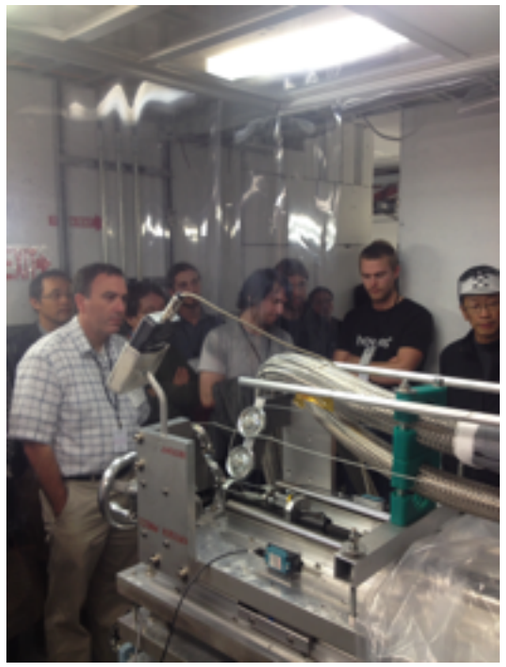
Discussion points:
Influence of harmonic number on serpentine channel acceleration requirements

Malek Haj Tahar

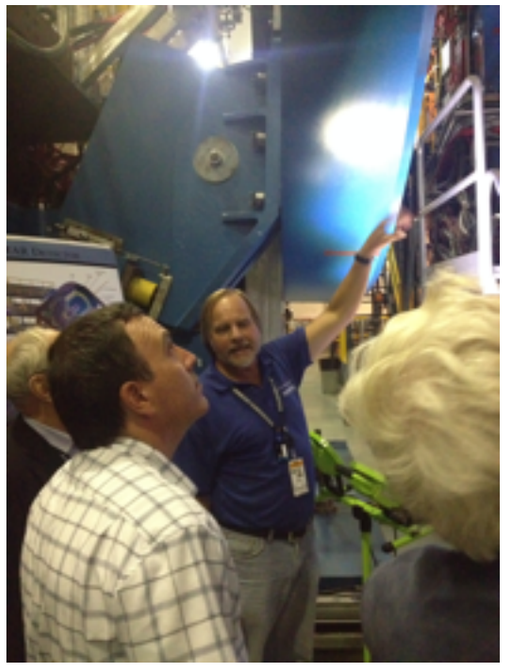
High power ring design studies for sub-critical reactor operation

- Energy choice of accelerator system crucial
- Presented a non-thorium solution
- ZGOUBI & OPAL ring simulations

then we toured…







Then we ate… again

7. Medical FFAGs & high power e-beams

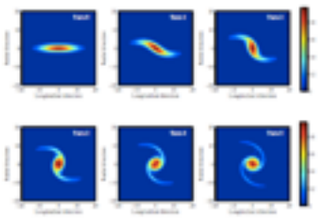
David Bruton

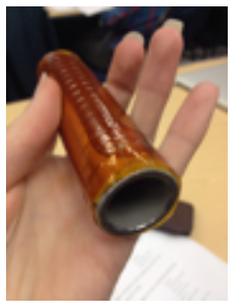
Low Energy FFAGs for isotope production

- design currently crosses integer
- Considered internal/external target
- Need to consider extraction mechanism

Antoine Cerfron

Space Charge in Fixed-Field Rings





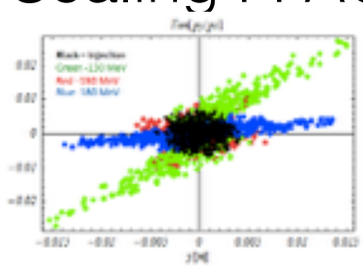
Dejan Trbojevic

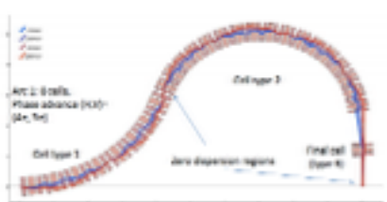
FFAG gantry design

- Fast energy variation - could allow organ tracking during treatment
- Challenges exist in scanning system

Jaroslaw Pasternak

Non-Linear Non-Scaling FFAG gantry design



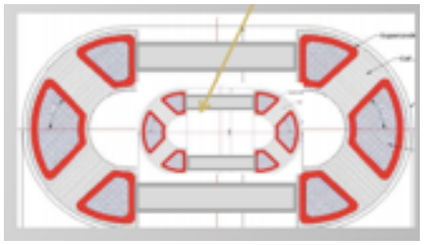


Discussion points:

Does the treatment at each gantry 'setting' need to cover the full energy range or not?

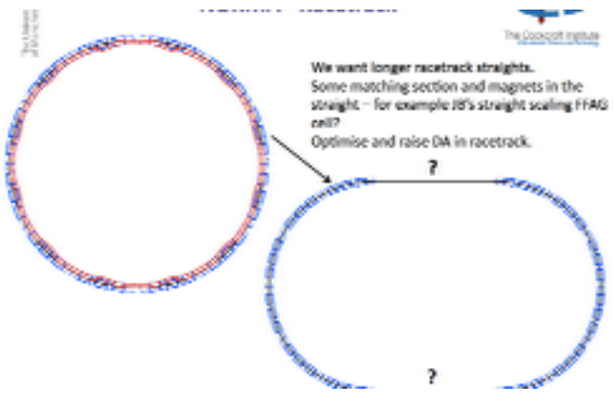
7. Medical FFAGs & high power e-beams

Carol Johnstone
Ion therapy FFAGs and imaging



Francois Meot

Medico-economical study of a FFAG based, multi-port simultaneous beam delivery hadrontherapy facility

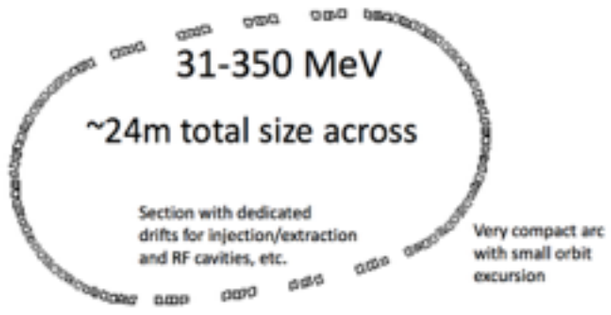


James Garland
NORMA
A NORmal conducting medical Accelerator

8. Injection/Extraction

Jaroslaw Pasternak

- Injection/extraction issues for pulsed machines
- Showed a number of designs including an egg-shaped one to allow inj/ext areas



Carol Johnstone

- Injection/extraction issues for CW machines
- Calculated acceleration rates & orbit separation

Discussion points:

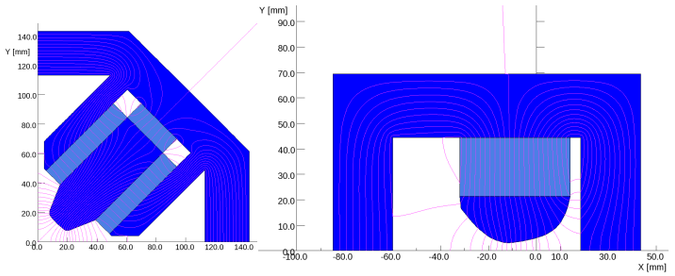
Experience from operating facilities e.g. PSI will be crucial to realise CW FFAG

Need to consider influence of harmonic number on serpentine channel & voltage requirement

(9. Cornell-BNL ERL FFAG)

10. New Proposal & Future

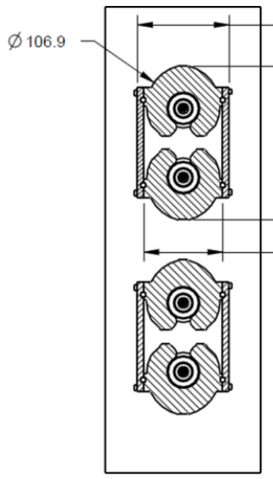
Wuzheng Meng



Ramesh Gupta & Mike Anarella

HTS magnets for eRHIC

Interesting round design which should be cheaper
Ends are expensive = no ends.
Engaging commercial companies as much as possible



Discussion points:

Small NC magnets look nice, in terms of cost the smaller the better... but are they actually harder to build?

For the round design there may be real end field effects, needs to be studied

Cost is the main issue to realise magnets for eRHIC, not technical challenge

10. New Proposal & Future

Bruce Dunham
Shielding & radiation protection

Don’t always need to go for ‘massive and passive’ shielding (though easiest if you can afford it)
Beginning calculations for the eRHIC FFAG option

Discussion points:
Uncertainty over beam loss rates for FFAG/ERL?
(Might even be easier because the energy acceptance is so large.)

Shinji Machida
Small scale FFAG test facility
Idea for flexible “versa-tron?” facility on end of FETS facility

Straight sections are required to realise some of these machines

Reduce dispersion in straights for cavities

We should use ‘chromatic’ or ‘zero-chromatic’
instead of ‘scaling’ or ‘non-scaling’

Summary of the summary…

- FFAGs continue to make a lot of progress
- New applications and uses emerging (ERL, post-acceleration AMS, BLAIRR etc…)
- There is still some work to go, particularly on high intensity aspects, but we are making progress
- Designs are ‘maturing’ in the design strategy, consideration of lessons learned from various projects etc..
- Many engineering challenges, but just as many novel solutions (helical coils, halbach magnets etc…)

Space-Charge 2015

Trinity College Oxford

March 23rd-27th

Space charge effects and beam loss mitigation in high intensity machines

Theoretical developments in Space Charge

Simulation methods and codes

Space charge issues in future proton and ion facilities

http://www.cockcroft.ac.uk/events/SpaceCharge15

FFAG'14

Thankyou to everyone at BNL for a great workshop
See you next year!